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ENERGY POVERTY IN PORTUGAL: WHICH HOUSEHOLDS ARE THE MOST VULNERABLE?

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Abstract: Energy poverty affects the health and wellbeing of households and contributes to poverty traps. In 2018, 20 percent of Portuguese households mentioned being unable to keep their home adequately warm. The results of a logit model using 2018 EU SILC data show that younger, less educated tenants living under poor dwelling conditions are among the most vulnerable in Portugal. Although energy poverty is directly linked to income poverty, not all poverty policies have been successful in solving both problems at the same time. Proper identification of those affected and associated socio-economic consequences is vital for adequate policy design.

1. Introduction

Recent studies on energy poverty in Europe have been promoted given increasing political recognition of the problem. More than 50 million people in the EU (European Union) are exposed to energy poverty, affecting mostly low-income households, single parents, families with children or old people, as well as households living in inefficient buildings and exposed to high energy expenses (EU Energy Poverty Observatory [EPOV], 2020). The EU Commission distinguishes energy poverty from poverty. The former is related to a set of adverse consequences to well-being, which aggravates respiratory, cardiovascular and mental health, exacerbated by low temperatures and stress associated with unaffordable energy bills. This definition, although not officially, has guided member states to assess the profile of individuals suffering from energy poverty.

In Portugal, cardiovascular and respiratory diseases have caused the death of approximately 3.7 thousand people in 2018, 397 of which driven by extreme low temperatures at home, which is also proven to aggravate pre-existent chronic diseases (Instituto Nacional de Saúde, Ricardo Jorge) (Brito, 2019). This paper aims at understanding the concept of energy poverty and identifying the energy vulnerable households in Portugal. I use the EU Survey on Income and Living Conditions (EU SILC) cross-sectional data for Portugal from 2018 to describe the results from a logit regression model on the impact of several dwelling conditions, household and individual characteristics, difficulty to pay for utility bills and location on self-assessed energy vulnerability, aggregating close to 30 thousand individual interviews.

Energy poverty has various causes which may build upon each other. Low income affects the capacity to pay for utility bills, with increasing electricity and gas prices compounding on income constraints. In turn, household funds are more limited to upgrade inefficient appliances, resulting in more costly energy (Council of European Development Bank - [CEB], 2019). These vicious circles can be broken when solving for the causes of poverty in the long run.

Substituting high energy consumption equipment, installing solar panels in dwellings, or even developing community heating schemes, such as district heating, are ways to reduce the financial burden of energy bills and ensure comfortable sustainable temperatures at home. Measures of this scale are expensive and difficult to implement, especially when the problem is not correctly identified and widespread.

The results of this paper suggest that close to 2 million people in Portugal, representing about 20% of the Portuguese population, are financially unable to keep home adequately warm and 460 thousand people were in arrears on utility bills during 2018, the most vulnerable being the young, less educated tenants living in poor dwelling conditions. Though social fare contributions have alleviated the burden of energy expenses, the problem persists. In fact, it seems hard to understand how a country with one of the most favourable climates in Europe is among the most vulnerable to cold and heat. Tackling energy poverty would alleviate public expenditure with health and climate pressure, while improving comfort and wellbeing of residents, reducing social exclusion and ultimately offering more opportunities for poor households to improve their income condition. This research aims to contribute to the characterization of Portuguese households that suffer from energy poverty. Being one of the first research papers on this topic in Portugal, the results provide valuable information to policy makers when designing public policies targeting poverty.

The remainder of the paper is organized as follows. Sections 2 and 3 provide a background on how energy poverty has been assessed in the EU and Portugal, respectively, followed by the literature review in Section 4. Section 5 describes the data and methodology and Section 6 shows the results. Furthermore, Section 7 presents the conclusion and discussion. Tables and figures are presented in the Appendix.

2. Energy poverty in the European Union

“Energy poverty” has been in the legal dictionary since the Lisbon Treaty (2007). The adoption of the Third Energy Package (TEP) in 2009 established that “*Member States shall take appropriate measures to protect final costumers, and shall, in particular, ensure that there are adequate safeguards to protect vulnerable costumers. In this context, each Member State shall define the concept of vulnerable costumers which may refer to energy poverty and, inter alia, to the prohibition of disconnection of electricity (gas) to such costumers in critical times*” (Electricity and gas directives 2009/72/EC and 2009/73/EC) (European Union, 2009a,b). Member states have therefore been assigned with the responsibility to deal with energy poverty within their own territories as found appropriate.

The EPOV (2020) is a new initiative by the European Commission to help countries combat energy poverty by improving the measuring, monitoring and sharing of knowledge. It suggests four primary indicators of energy poverty, two of which related to expenditure and income of households (from Household Budget Survey – HBS), the other two based on self-reported experiences of limited access to energy supply (EU SILC).

The UK (United Kingdom) was one of the pioneers in targeting energy poverty as a relevant policy matter. In 1988, UK data showed that the average household expenditure on domestic energy was around 5 percent, while the 30 percent lowest income household spent on average 10 percent. As such, expenditure at a level equivalent to twice the median is disproportionate, which would only occur with expenditure on housing and domestic fuel (Isherwood and Hancock, 1979). Boardman (2010) thus identified the fuel poor as those who could not have adequate energy services for 10 percent of income. The “10 percent approach” became the UK’s official definition since 1991[1] and was leveraged by the EPOV, although not officially, creating

[1] The Low Income High Cost approach proposed by Hills’s Final Report of the Fuel Poverty Review became the official definition in England in 2012 (Hills, 2012).

the so called "high share of energy expenditure in income" indicator.

The EPOV (2020) further suggests that households whose absolute energy expenditure is below half the national median might be exposed to energy poverty. The "low absolute energy expenditure" indicator shows an ambiguous proportion of population who can either dangerously under-consume energy or live in dwellings with high energy efficiency standards. This is a relatively new indicator used in Belgium to complement other expenditure and self-reported indicators.

Figures 1 and 2 in the Appendix show that higher GDP per capital is typically associated with less energy poverty levels. The relationship between energy deprivation and wealth is more straightforward using self-assessment-based indicators (Figure 2) than expenditure-based ones (Figure 1).

The Netherlands is one of the countries with highest GDP per capita in the EU (€39,163 in 2018) and is ranked first in lowest population share with low absolute energy expenditure (4.4 percent) and third in lowest population share with high share of energy expenditure in income (10.7 percent). By contrast, Finland and Sweden are also among the richest countries in the EU and have the highest share of population with both low absolute energy expenditure (29.9 and 24.3 percent, respectively) and high share of energy expenditure in income (22.3 and 28.7 percent, respectively). One possible explanation for this phenomenon is related to the district heating system in place in both countries.

District heating is an intelligent way to heat homes, schools and other premises of the district. Energy is supplied by a central heating plant and spreads warmth around the district through a system of insulated pipes and residential and commercial heating facilities, instead of every building having its own boiler. It is hard to say whether the population proportion with high share of energy expenditure in income is within the proportion with low absolute energy expenditure with the available data but the current district heating may explain the odd disparities presented by both energy indicators, since the distribution of energy across each country is determined by the energy endowments of districts and whether community energy schemes are in place. District heating operations only account for 50 percent of the energy market and compete with whatever alternative is available on the local markets for heating (Lundqvist, 2019).

Hungary, Bulgaria and Slovakia have relatively low GDP per capita but are among the top countries with less population share in both expenditure-based energy poverty situations, possibly driven by general low access to energy supplies and energy inefficient buildings.

The relation between income and energy poverty is clearer in Figure 2. Austria, Finland, Luxembourg, Netherlands and Sweden have a residual share of population unable to keep home adequately warm (between 1.6 and 2.3 percent), compared to Bulgaria, Lithuania, Greece, Cyprus and Portugal (between 21.9 and 33.7 percent). Similarly, Netherlands, Czech Republic, Sweden and Austria have a very low share of households in arrears on utility bills (between 1.5 and 2.4 percent), compared to Greece, Bulgaria, Croatia and Romania (between 14.4 and 35.6 percent). It is also interesting to note that southern countries, such as Greece, Cyprus, Portugal, Italy and Spain, seem to show higher levels of energy poverty than northern countries, which can be associated with higher poverty levels in general.

3. Energy Poverty in Portugal

Figure 1 shows that, in 2015, 15.1 percent of households in Portugal had a share of energy expenditure in income that was more than twice the national median share – in line with EU average (14.6 percent) – but only 6.8 percent have a "low absolute energy expenditure", much lower than EU average (14.6 percent[2]). Figure 2 suggests that 4.5 percent of households were

[2] Possibly skewed by richer countries higher energy efficiency, as seen above for Finland and Sweden.

in arrears on utility bills (460 thousand citizens), while being the fifth country in the EU with the highest share of population unable to keep home adequately warm (19.4 percent or close to 2 million people), much higher than EU average (7.3 percent). The low percentage of households in arrears on utility bills indicates that there might exist hidden realities in which households are not able to heat their homes at all.

It is clear that Portugal is one of the EU member states where energy poverty is both most severe and least recognised. This phenomenon appears to be expanding in peripheral EU countries, encompassing populations beyond the low-income cluster, contrary to norther and western countries where energy deprivation occurs among specific margins of society (Bouzarovski, 2018). Capturing energy poverty via income-based indicators is less meaningful where domestic energy deprivation is concentrated in rural and peripheral regions with poor-quality housing and reduced access to affordable fuels. Given that Portugal meets these criteria, this paper focuses on the qualitative self-assessment on whether families feel cold in their homes and characterizes the corresponding household's profile.

4. Literature Review

The UK was the first EU country to add energy poverty to the political and research agenda. Isherwook and Hancock (1979) suggested that energy poverty should aggregate households spending more than twice the median proportion of income on all energy resources, motivated by UK data showing that this phenomenon only happened to the 30 percent lowest income families. Boardman (1991) leveraged this idea and targeted energy poor households as those that need or would need to spend more than 10 percent of their income to heat their homes to an acceptable level, which would occur mostly to those living in energy inefficient dwellings and unable to afford the current level of energy prices. The so-called *10 percent approach* became the official definition of energy poverty in the UK (in England until 2012) and has been recently adopted, although not officially, at the EU level. From 2001 onwards, UK policy enlarged the scope of energy poverty to all energy vulnerable households, i.e. older households, families with children, and individuals who are disabled or suffering from long-term illness (Department of Trade and Industry [DTI], 2001). The idea was to aid those whose health might be affected by the cold.

In 2011, John Hills from the UK Centre for Analysis of Social Exclusion, criticised the energy vulnerability definition arguing that this led to relatively richer households receiving unnecessary assistance without even recognizing the calibre of the homes. The *10 percent approach* was also based on a fixed threshold set more than 20 years ago which made the measurement sensitive to changes in price level technicalities within its calculation, also encompassing families clearly not poor. John Hills then proposed the Low Income High Cost (LIHC) approach identifying the energy poor if "*they required fuel costs that are above the median level"* of the whole population and *"were they to spend that amount they would be left with a residual income below the official poverty line".* This became the official definition in England since 2012 (Hills, 2012).

Legendre and Ricci (2015) used the French housing survey "Enquete Longement 2006" (INSEE, 2013) to compare the two measurements used in the UK and showed that different indicators produce different results: with the *10 percent approach,* 17 percent of the population were energy poor compared to only 9 percent using the *LIHC approach*. The study further concludes that people living alone, especially retired, are significantly more exposed to fuel vulnerability, while being a homeowner and highly educated is associated with lower vulnerability. The propensity to be energy poor is also influenced by the heating equipment and the type of energy used for cooking, according to the study.

Using the European Community Household Panel data from 1994 and 1997 inclusive, Healy (2003) calculated energy poverty in Ireland using a combination of self-reported and factual indicators, such as whether households were satisfied with their heating facilities, whether they were able to heath their homes or pay for utility bills on time, as well as the type of heating systems (central heating or electric storage heaters) or whether the dwelling had damp walls or floors and rotten window frames. The author found that energy poverty is highest among low-income groups, single parents, unemployed, and those living in multi-family dwellings, mainly driven by households reluctant to invest in energy efficiency rather than property rights' failures and transaction costs (for example, tenancy situation).

A larger study from the European Partnership for Energy and Environment (2009) evaluated the impact and causes of energy poverty in Belgium, France, Italy, Spain and the UK, in a multidimensional way. The research showed that tenants, single people and pensioners are the most affected by energy poverty, mainly caused by low energy efficient housing, rising fuel prices and low income. Tenants, in specific, are thought to have less control over their homes when it comes to fixing heating and structural building problems. Pensioners, on the other hand, have usually low income and spend more time at home than active people, hence requiring higher energy needs.

Even though the United States (US) have not formally recognized energy poverty as a problem at the federal level, the availability of data makes is easier to produce relevant statistical research. Mohr (2018) used data from the US Energy Information Administration's 2009 Residential Energy Consumption Survey (RECS) to describe US households' fuel expenditure and understand fuel vulnerability among the households spending on heating more than twice the median of the state. The results show that renters pay less in total for fuel than homeowners, but fuel expenditure per square foot is higher for renters. Renters living in fuel inefficient housing are disadvantaged when the landlord does not weatherize or upgrade the equipment as it might affect future bills – split incentive dilemma (Bird and Hérnandez, 2012). On the other hand, owners are more likely to use natural gas while renters use more electricity, and because electricity prices are usually above gas prices, renters are in disadvantage relative to owners.

Most factors influencing the odds of being fuel poor are linked to the level of income, such as having college education, working full time, being married, young and white. The presence of children, contrary to what other literature suggests, has not a statistically significant impact.

5. Data & Methodology

Since there is no dedicated survey on energy poverty in the EU, researchers have been relying on data collected for other purposes (EPOV, 2020). In this paper, EU SILC cross-sectional data from 2018 is used to characterize households more prone to be energy poor in Portugal (29,057 individuals observed[3]) using a logit regression model.

$$p = \frac{1}{1 + e^{-(\beta_0 + \beta_1 arrears + \ _2 noisy + \beta_3 \boldsymbol{dwl\_conditions} + \beta_4 \boldsymbol{hh\_characteristics})}}$$

p: *probability to be energy poor, i.e. to be unable to keep home adequately warm.*

arrears: *dummy on whether the household has been in arrears on utility bills during the past 12 months.*

noisy: *dummy on location, i.e. whether the household feels noise from neighbours or from outside to be a problem for the household.*

dwl_conditions*: dwelling specific conditions, such as leaking roof, damp walls, rot in the windows, not enough light, being a house, the number of rooms, and age of the contract.*

hh_characteristics*: household and individual specific characteristics, such as age, gender, education, health, household size, tenancy, unemployment and disability.*

The EU SILC is the EU reference for comparative statistics on income distribution and social exclusion at the European level, in the *"Program of community action to encourage cooperation between Member States to combat social exclusion"*. According to the Commission Regulation (EC) No 1982/2003 on sampling, weighting factors must be calculated to account for the units' probability of selection and non-response and adjust the sample to

[3] Excludes missing values for some variables of the sample.

external data relating to the distribution of households' and individuals' socio-economic characteristics (in theory, the probability of being sampled equals the inverse of the respective weight). The following section summarizes the descriptive statistics of the relevant variables while using the weights to provide a closer view on the true population statistics.

Capacity to keep home adequately warm

To measure energy poverty, I use a subjective indicator the literature has demonstrated to be an important reflector of the feeling of material deprivation felt by households who cannot warm their home. It is a dummy variable on the EU SILC question which asks whether households could afford to keep their homes adequately warm during 2018, regardless of whether the household needs to keep it adequately warm. Subjective or self-reported indicators have been argued to be unreliable if people feel ashamed to admit they have incapacity to feel comfortable with home temperature. However, it assesses the respondent's feeling and perception towards energy poverty and comfort. It also overcomes the expenditure approaches' problems of not accounting for desired expenditure on domestic energy, especially when it is higher than actual expenditure (Churchill and Smyth, 2020). Even though there is no official definition, this is one of the primary indicators used by the EPOV in its 2018 energy poverty report. The EU SILC dataset for Portugal shows that 20.3 percent of households interviewed were unable to keep their homes adequately warm.

Arrears on utility bills

The literature shows that some households face difficulties associated with domestic energy costs. The first energy poverty factor to be assessed is whether households were in arrears on utility bills more than once during the past 12 months, i.e. whether they have been unable to pay on time for utility bills (heating, electricity, gas, etc.) for the main dwelling due to financial difficulties. This event happened to 4.2 percent of households, 44.2 percent of which were unable to keep their homes adequately warm, which indicates that the odds of falling under energy poverty are higher for people in arrears on utility bills. On the other hand, only 9.2 percent of those unable to warm their homes were also unable to pay for utility bills on time, hence suggesting that there might be other determinants of energy poverty, regardless of how much households pay or need to pay for utility bills.

Location

The literature suggests that energy poverty tends to exist in rural areas given lower levels of industrialization and where more severe climate. Since EU SILC data does not provide information on household's location, I use the self-assessment of whether the respondent feels "noise from neighbours or from outside" to be a problem for the household as a proxy for living in an urban or suburban/rural area, or at least to provide a context of the external environment of households' location. The more noise from outside either from traffic, businesses or factories, the closer to a city the household is located.

Dwelling conditions

This paper considers a combination of dwelling characteristics to assess the energy efficiency of the home: whether it has a leaking roof, damp walls/floors/foundation, or rot in window frames or floor; whether there is not enough daylight coming through the windows; the type of dwelling (house versus flat); the number of rooms in the dwelling; and the age of the propriety contract as a proxy for the age of the dwelling.

In 2018, 27.1 percent of households surveyed mentioned having a leaking roof, damp walls/floors/foundation, or rot in window frames or floor, 34.8 percent of which felt too cold inside their home. Almost half of those unable to keep home warm (46.6 percent) had their homes in these conditions. Additionally, 10.2 percent of households mentioned not having enough daylight in the dwelling and 32.5 percent of these were also unable to adequately warm the home. 45.7 percent of households in dwellings with leaks, damp or rot as well as not enough daylight have difficulties in heating their home.

The bigger the size of the dwelling, the more energy resources households would require to maintain a comfortable temperature. To measure the dimension of the dwelling, I use an indicator of the number of rooms as well as a dummy that determines whether the dwelling is a house or a flat (houses tend to be larger and more spacious than flats). In 2018, 55.4 percent of the sampled population and more than half (57.3 percent) of those unable to keep home adequately warm was living in a detached/semi-detached/terrace house. Nevertheless, only 21.1 percent of households living in a house were energy poor. Most dwellings (35 percent) have 4 rooms, including houses (31.4 percent). 24 percent of houses have more than 6 rooms compared to only 3.6 percent in flats.

Older homes tend to be supported by obsolete structures even more given growing restrictions on energy efficient standards for newly built dwellings. Among those interviewed, property contracts are on average 22.5 years old, and most contracts are over 20 years old. Nonetheless, there is no statistically significant difference in the mean age of contracts between energy poor and non-energy poor households, as well as between tenants and homeowners.

Household & Individual Characteristics

Household and individual socio-economic characteristics are also taken into account, such as disposable income, household size, age, education, retirement, tenure type, unemployment, disability, health, and gender.

Being materially deprived is thought to be mostly determined by low income levels and energy poverty itself is a consequence of income poverty. Even if income is not scarce enough to pay for utility bills on time, it may not be enough to upgrade the energy efficiency of the home. In this study, income is the sum of the disposable income of each household (net of taxes and including transfers), imputed rent[4] and the value of goods produced for own consumption[5] divided by the equivalized number of adults[6] (aged 16 or over) living in the household. In 2018, the median annual disposable income per household in the sample was €17,968 and the mean was €21,210, which is not statistically different from the real average population disposable income per household of €33,196. The median annual disposable income per person was €7,750 and the mean was €10,178, also not statistically different from the population average of €12,773. 33.8 percent of sampled households were living below the poverty line[7], 31.8 percent of which being unable to keep home adequately warm.

Age tends to be another important determinant of energy poverty given its influence on the individual profile. On the one hand, health is more fragile and tolerance to lower temperatures is reduced for older people. There is a tendency for the elderly to live alone as younger family members move on with life and partners end up passing away. On the other hand, younger people have lower income levels, unstable employment, and consider energetic comfort as a secondary necessity. The average age of the sampled population is 28 years old, while most of the individuals are over 50 years old. Pensioners account for 25.8 percent of the sample, and 35.7 percent mentioned being in "bad" or "very bad" health conditions. Although somehow correlated to the levels of income, education attainment is also taken into account.

Another energy poverty factor discussed in the literature is the tenure type of the dwelling, i.e. whether the home is owned or rented by the household. Tenants tend to have less control over

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[4] The imputed rent refers to the value that needs to be imputed for all households that do not report paying full rent, either because they are owner-occupiers or they live in accommodation rented at a lower price than the market price, or because the accommodation is provided rent free.

[5] The value of goods produced for own consumption refers to the value of food and beverages produced and also consumed within the same household and shall be calculated as the market value of goods produced deducting any expenses incurred in the production.

[6] Assigns a value of 1 to the first household member, of 0.7 to each additional adult and of 0.5 to each child. Because there is no data on the number of children in household, I treat each member as an adult.

[7] Being in risk of poverty implies having an annual income lower than 60% the population median disposable income per person, which consisted of €6,014 in 2018 and aggregates 22 percent of the population.

what can be changed in the dwelling compared to homeowners. On the other hand, homeowners need to take responsibility and financial burdens to maintain energy efficiency. In the sampled population, 24.9 percent of households are tenants, 30.8 percent of which are energy poor.

Most households in the sample (32 percent) are comprised of 2 adults, while 10 percent of the population lives with more than 4 adults and 10.6 percent lives alone. Among those in energy poverty, 14 percent are living alone, and 13.3 percent live with more than 4 people.[8]

6. Results

This section describes the results from a logit regression model[9] on the impact of several dwelling conditions, household and individual characteristics, being in arrears on utility bills, and location on energy vulnerability, i.e. the propensity for households to be unable to keep their homes adequately warm. Table 1 in the appendix displays the results of the model. For each model (from (1) to (5)), the first column shows the parameter estimates (β) and t-statistics in parentheses, while the second and third columns show the average marginal effects and the odds-ratios, respectively. All models control for both arrears on utility bills (*arrears*) and living near a city (*noisy*).

Model (1) shows the impact of both *arrears* and *noisy* on energy poverty as well as the following dwelling conditions: i) whether the dwelling has a leaking roof, damp walls/floor/foundation, or rot in the window frames or floor (*leaks*); ii) whether there is not enough daylight in the dwelling (*dark*); iii) if the dwelling is a house (*house*); iv) the number of rooms in the dwelling (*rooms*); v) and the age of the contract as a proxy for the age of the dwelling (*contract age*). These variables explain 5.3 percent of the variability on the probability

[8] Data on the number of children within the household was not available.

[9] Corrects for heteroskedasticity using robust standard errors. The choice between the logit and probit models is irrelevant.

to be energy poor (Pseudo R-squared = 0.053).

Models (2) and (3) show the impact of household/individual specific characteristics on the propensity to be unable to heat the dwelling, in addition to *arrears* and *noisy.* Household characteristics include: i) *age/retirement*[10] ; ii) level of education (*education*); iii) self-assessment of health conditions (*health*); iv) the number of adult members in the household (*household size*); v) whether the dwelling is rented or owned (*tenant*); vi) if the individual is a female (*female*); vi) and whether the individual is *unemployed* or *disabled.* Models (2) and (3) explain 6 percent of the variability on the propensity to be energy poor (Pseudo R-squared of 0.062 and 0.061, respectively).

Models (4) and (5) show a combination of both dwelling conditions and household/individual specific characteristics, apart from *arrears* and *noisy*, and explain approximately 9 percent of the variability of the dependent variable (Pseudo R-squared of 0.088 and 0.089, respectively).

Households in arrears on utility bills at least once during the past 12 months are 2.3 times more prone to be unable to keep their homes at an adequate temperature. *Arrears* is statistically significant and increases energy poverty probability by at least 12 percentage points. According to the literature, energy poverty is directly linked to income poverty and material deprivation. As such, comfort is usually a secondary necessity for poorer households. Those who struggle to pay their bills tend to save more on energy and only use it when necessary, foregoing comfort in the first place. This phenomenon seems to affect more the younger generations than the elderly: individuals in arrears on utility bills in their 20s have 3 percentage points more probability to be energy poor than those aged 70 (marginal effects of 13 percentage points for the young, compared to 10 percentage points for the elderly). The impact of being in arrears is also higher for less educated individuals: the marginal effect of *arrears* for those without

[10] Need to be separated due to multicollinearity.

education is 14 percentage points, while for people with higher education is 8 percentage points. Not surprisingly, the impact is also larger for the unhealthy than healthy people - the marginal effect of *arrears* for those in "very bad health" is 17 percentage points, while for those in "very good health" is 8 percentage points. For young and less educated individuals, it is usually more difficult to have a solid and stable income source which consequently affects the payment of bills. Younger people, generally healthier and less vulnerable to chronic, cardiovascular or respiratory diseases, do not need to care about heat as much as older people and therefore might not need to use alternative sources of heating, such as fireplaces, wood, warmer blankets, etc.

Noisy is a dummy on whether the respondent feels that noise from the outside is a problem for the household. It gives more context on the location and the outside environment of the dwelling (such as noise from neighbours, traffic, business or factories, which usually happens in urban areas). The literature suggests that energy efficiency is lower in rural isolated places. Yet, the results show, that, in Portugal, households living near cities are 1.4 times more prone to be energy poor. This is an important result since more energy inefficiency might not necessarily mean more energy poverty, since in rural areas people tend to use fireplaces and wood to keep themselves warm and this might not represent and additional financial burden. The concentration of younger people is higher in urban than in rural areas, for providing more job opportunities and other attractions, and the propensity to be energy poor near cities is higher for younger than for older people.

House is a dummy for whether the home is a detached/semi-detached/terraced house (versus a flat) and # *rooms* counts the number of rooms in the dwelling. Both variables provide more detail on the size and structure of the home. Living in a house is associated with a positive statistically significant effect on the propensity to be energy poor with marginal effects of around 4 percentage points, *ceteris paribus*. Households living in a house are more prone to have heating inefficiencies given the bigger size and more spacious rooms. *Rooms* on the other hand, is not statistically significant. The number of rooms in the dwelling is not very different if the household lives near the city or not, but houses are more common in quieter isolated places, compared to flats. However, the chances of being unable to adequately heat a house is not different if the house is located near the city or not.

Having a leaking roof, damp walls/floor/foundation, or rot in window frames or floor and not having enough daylight in the dwelling are associated with lower energy efficiency, hence more difficulty in keeping home adequately warm. The results show that the variables *leaks* and *dark* increase the probability to be energy poor by approximately 10 and 2 percentage points, respectively, at a statistically significant level of at least 5%. The interception of both conditions (*leaks**dark*) has a marginal effect of 4 percentage points, *ceteris paribus.* These conditions tend to be more common in older homes, but the results for *contract age* are mixed (the variable is not statistically significant in model (5)) and it does not impact the marginal effects of any of the aforementioned dwelling conditions. On the other hand, the marginal effect of *leaks* on the propensity to be energy poor is higher for younger than for older people (11 percentage points for those in their 20s compared to 9 percentage points for individuals in their 70s).

The results also demonstrate that tenants are 1.7 times more prone to be unable to keep home warm than homeowners at a statistically significance level. Income is an important factor given that homeowners earn on average more than tenants, but the misalignment of incentives between tenants and owners is also relevant. In fact, 40 percent of tenants live in dwellings with a leaking roof, damp walls/floor/foundation, or rot in window frames or floor, compared to 28 percent of homeowners; 16 percent of tenants also do not have enough daylight in the dwelling compared to 10 percent of property owners. Younger tenants have higher chances to be unable to keep home adequately warm, but the inequality is even more striking in terms of education. The difference between the marginal effects of individuals in their 20s and 80s is of 2 percentage points (9 and 7 percentage points, respectively), but tenants with no education have

4 percentage points more probability to be energy poor compared to those with higher education (9 and 5 percentage points, respectively). Tenants living alone are not more exposed to energy poverty than those living with two or more adults, even though living with the parents is an advantage for younger people.

Health is another variable with considerable statistically significant impact on energy poverty propensity. *Ceteris paribus,* individuals that mentioned having "very bad" health conditions are 8 percentage points more prone to be unable to heat their homes at an adequate level than those reporting "good" or "very good". This might be driven by the fact that health itself changes the perception of what is adequate temperature for the dwelling. But the impact of health does not seem to be dependent on the age. The marginal effect of health for people in their 30s is of 6 percentage points, compared to 5 percentage points for those in their 70s. Additionally, being retired produces the same *health* marginal effect as non-retired (5.3 percentage points).[11]

Younger people are more exposed to energy poverty in Portugal, but *age* by itself has a small marginal impact, even though statistically significant. On average, one additional year of age is associated with a 0.1 percentage point decrease in the probability to be energy poor. Contrary to the literature, being retired does not have a statistically significant impact on energy poverty vulnerability at any significance level. However, higher education is associated with larger pensions which explains more about energy vulnerability than being retired by itself. Less educated people are indeed more prone to be energy poor regardless of the age, with a statistically significance level of 0.1%.

Poverty is directly linked and caused by low income levels. *Log(disposable income per person)* is the logarithm[12] of the sum of household disposable income, imputed rent and the value of

[11] Note that 75% of observations reported having "good" or "reasonable" health, which may skew the results.

[12] The logarithm is used to skew the values to a more normal distribution.

goods produced for consumption divided by the equivalent number of adults in the household. Nonetheless, income by itself does not have a statistically significant impact on the capacity to keep home adequately warm. Being unemployed or disabled does not increase the probability of being energy poor, at a 5% significance level. The support of the state to these social groups may explain why they are not more exposed to energy poverty.

7. Discussion & Conclusion

For thousands of people across the EU, their health and wellbeing are impacted by the lack of domestic energy options. In 2018, 20 percent of Portuguese households were unable to keep their home adequately warm. Extreme low temperatures at home are associated with cardiovascular and respiratory diseases, while the difficulty to pay bills and discomfort at home may drive mental health instability. This phenomenon is surprisingly more striking in warmer southern European countries where low temperatures during the winter do not justify investment in better housing infrastructure for the poor. To a certain extent, energy poverty (as part of the multidimensional nature of poverty) is not only driven by low economic growth but also jeopardizes economic growth itself, fomenting the so-called "poverty trap". Poverty traps can be broken by solving for long run inefficiencies and market failures.

Different identification approaches lead to different population focus. Linking energy poverty to income levels is more straightforward using qualitative self-assessment indicators of temperature discomfort than quantitative expenditure approaches. For example, a fall in absolute energy consumption could be either associated with lower capabilities to pay for utility bills or an indication of better well-being of households, such as the cases of Netherlands and Finland. The inexistence of an official definition in the EU has delayed relevant data collection, research and policy design. Energy poverty hits all countries and regions in different ways and should be therefore tackled at the national/local level. Yet, policy dialogue among member states and the coordination between institutions should be improved, while pushing towards a harmonized definition to inform data collection.

This paper represents one of the first studies of energy poverty in Portugal. The results show how several socioeconomic and dwelling factors influence a subjective self-reported indicator of energy poverty in Portugal. Although the model aggregates data for only one year, it provides research avenues that can be explored in future studies.

The results obtained suggest that, although households in arrears on utility bills are 2.3 times more exposed to energy poverty, the marginal effects are higher for the young and less educated individuals, who are not totally captured by the social fare. The social fare is the only energy poverty policy in place in Portugal, which provides financial assistance on electricity and gas bills applicable to households receiving old age benefits, social exclusion or unemployment subsidies, family allowances, old age and invalidity pensions. Families whose income is lower than a certain threshold are also eligible. The results also suggest that disabled and unemployed individuals are less exposed to energy poverty which may indicate that the policy is working for them. Health conditions change the individual's perception of temperature and is an important contributor to the self-assessment of energy poverty. Nonetheless, health marginal effects do not depend on age. Young less educated people, on the other hand, tend to be more exposed to energy poverty, although with small marginal effects. Income has no statistically significant impact.

Governments employ energy subsidies to combat energy poverty in the short run but targeting for long run energy efficiency goals would contribute to improving the quality of homes and reducing the energy cost burden to low-income households (CEB, 2019). Improving energy efficiency would produce nation-wide benefits such as lower greenhouse gas emissions and stress on energy grid systems, boost GDP growth by further employment for home construction and reducing energy dependency. The results show that, in 2018, almost 30 percent of Portuguese households were living with leaking roof, damp walls, floors or foundation, or rot in window frames while having twice the probability to be energy poor compared to households with proper dwelling conditions. These environments are more common in old homes and with larger marginal effects on younger generations.

Another important result is related to the tenancy situation of households: 40 percent of tenants live with leaking roof, damp walls, floors or foundation, or rot in window frames, compared to 28 percent of homeowners. Tenants are 1.7 times more exposed to energy poverty with a larger impact on the young and less educated, who are thought to have less control over their homes when it comes to fixing heating and structural building problems. Since 2010, the property owners are obliged to prove the degree of energy efficiency before renting accommodation. Nevertheless, informal contracts exist in Portugal and tend to be cheaper by avoiding taxes and energy efficiency standards. Supported by regulation on efficiency minimum requirements, as well as training and dissemination of information, policy measures should incentivize low-income owners or tenants to renovate and regularly maintain their properties through lower (income) taxes or higher subsidies, lower interest rates or longer periods for loan repayment, so as to disincentivise informal contracts with no additional costs (Berry, 2019; Schleich, 2019; Wadud, Graham, and Noland, 2009). Future studies should try to understand the structure of savings to energy efficiency among low-income renters and owners in order to correct for the split incentive dilemma.

In terms of public housing, more attention should be paid to households' feedback on energetic comfort. For example, the Lisbon Municipality launched a project to update the needs of residential low-income households. The program aims at guaranteeing minimum sanitary and energetic comfort standards.

It is clear from the results that the marginal effects of several energy poverty determinants are higher for younger generations. The integration of young people in the labour market is still an issue in Portugal, especially for the low skilled, making them more exposed to poverty. In 2019, 18.3 percent of people between 16 and 25 years old were unemployed. Regardless of the level of education, young people find it hard to integrate in the job market, while facing difficulties in projecting their future and investing in wellbeing. Many end up staying with their parents until their 30s. Labour market inefficiencies (such as employee protection schemes and "green receipts"), together with no proper skills training, incentivize many young people to either stick to short-term precarious jobs or leave the country. More contact with the job market should be promoted during high school and university (through partnerships with companies) as well as the creation graduate programmes and career mentoring within corporations.

Being a primary necessity, there are clearly market failures in heating supply with the most effective solutions being too costly. It is evident that many governments only use energy subsidies given the lack of funds to solve long run causes of energy poverty, but these do not allow consumers to exit from their poverty condition (European Energy Network [EnR], 2019). Community heating schemes have proven to successfully correct heating inefficiencies and overcome energy poverty within districts, but the expensive technology may not just be justified for warmer poorer countries. Policy makers should focus on a combination of specific structural and short-term measures to combat energy poverty, regardless of the approach, and ultimately aim at raising national income.

8. Appendix

Figure 1. Quantitative expenditure-based indicators of energy poverty in the EU in 2015 vs GDP per capita. Source: EPOV and Eurostat

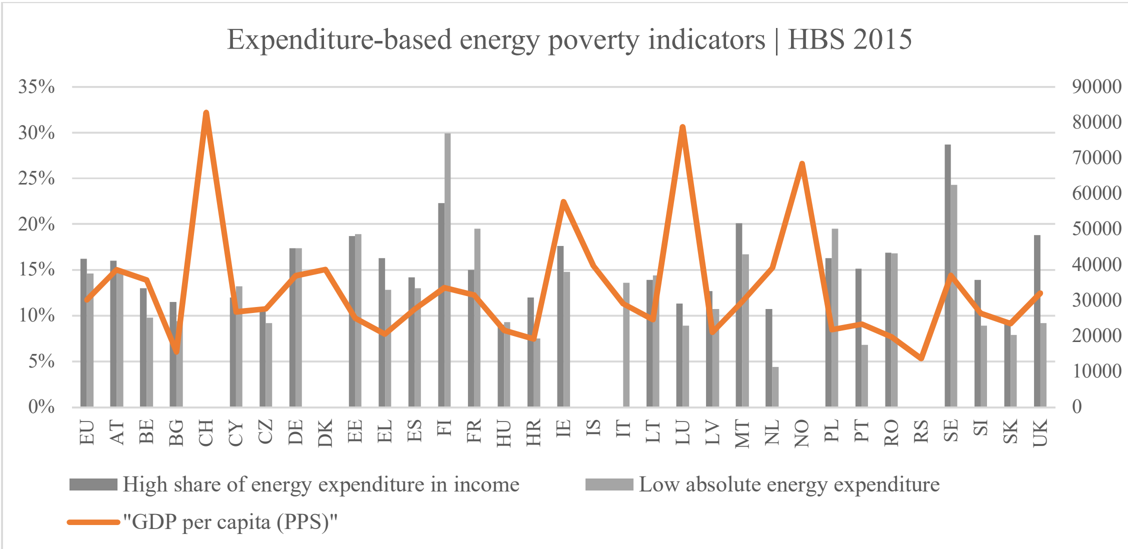

Figure 2. Quantitative self-assessment indicators of energy poverty in the EU in 2018 vs GCB per capita. Source: EPOV and Eurostat.

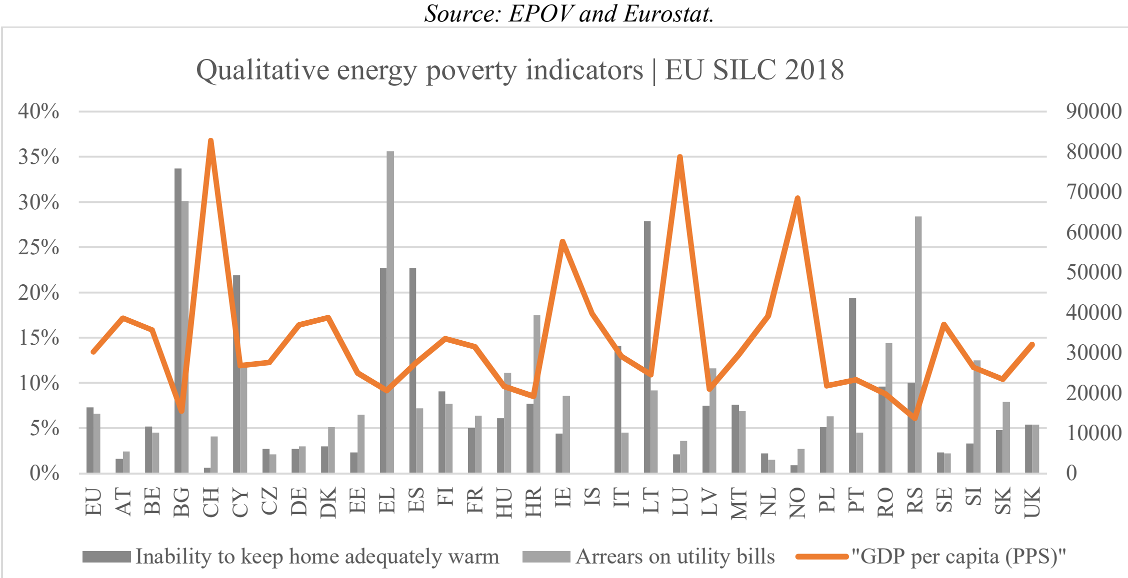

Table 1. Econometric results from a logit regression model on the propensity to be energy poor. Database: EU SILC. t-statistics in parentheses.
** $p < 0.05$; ** $p < 0.01$; *** $p < 0.001$*

Is the household unable to keep home adequately warm?	(1)			(2)			(3)			(4)			(5)		
	β (t-stat)	Marginal effects	Odds ratio	β (t-stat)	Marginal effects	Odds ratio	β (t-stat)	Marginal effects	Odds ratio	β (t-stat)	Marginal effects	Odds ratio	β (t-stat)	Marginal effects	Odds ratio
Arrears on utility bills	0.913***	0.135	2.492	1.033***	0.151	2.810	1.046***	0.154	2.845	0.822***	0.11681	2.27479	0.834***	0.11867	2.30166
	(15.23)			(-31.54)			(17.50)			(13.10)			(13.29)		
Noisy	0.340***	0.050	1.405	0.348***	0.051	1.416	0.348***	0.051	1.416	0.328***	0.05	1.39	0.326***	0.05	1.39
	(9.09)			(-31.54)			-9.67			(8.66)			(8.61)		
Dwelling Characteristics															
leaks/damp/rot	0.774***	0.114	2.168							0.699***	0.09941	2.01272	0.701***	0.09976	2.01524
	(22.23)									(19.60)			(19.64)		
not enough daylight	0.180**	0.027	1.198							0.134*	0.01909	1.14375	0.135*	0.01927	1.14496
	(2.74)									(2.02)			(2.04)		
house	0.289***	0.043	1.335							0.339***	0.04817	1.40344	0.339***	0.04821	1.40303
	(8.40)									(9.59)			(9.60)		
# rooms	-0.0638***	-0.009	0.938							-0.0255	-0.0036	0.97486	-0.0284	-0.004	0.97195
	(-3.74)									(-1.41)			(-1.58)		
contract age	0.00575***	0.001	1.006							0.00307*	0.00044	1.00308	0.00076	0.00011	1.00076
	(4.94)									(2.38)					
leaks/damp/rot & not enough daylight	0.306***	0.045	1.359							0.260**	0.03696	1.297	0.268**	0.03815	1.39
	(3.47)									(2.89)			(2.99)		
Household Characteristics															
log(disposable income per person)				0.0202	0.003	1.020	-0.0226	-0.003	0.978	0.0256	0.00363	1.0259	-0.0103	-0.0015	0.98978
				(0.70)			(-0.79)			(0.87)			(-0.35)		
age				-0.00698**	-0.001	0.993				-0.00735*	-0.001	0.99267			
				(-6.62)						(-6.70)					
education				-0.181***	-0.027	0.834	-0.145***	-0.021	0.865	-0.194**	-0.0276	0.82364	-0.165***	-0.0236	0.84751
				(-14.16)			(-11.35)			(-14.66)			(-12.56)		
retired							0.04	0.006	1.039				0.02	0.00	1.01564
							(0.99)						(0.38)		
health				0.437***	0.064	1.548	0.430***	0.063	1.537	0.380***	0.05406	1.4628	0.373***	0.05312	1.45234
				(26.49)			(26.26)			(22.61)			(22.32)		
household size				-0.001	0.000	0.999	0.0291*	0.004	1.029	0.00346	0.00049	1.00346	0.0308*	0.00438	1.03127
				(-0.08)			(2.33)			(0.26)			(2.38)		
tenant				0.560***	0.082	1.750	0.562***	0.083	1.755	0.548***	0.07791	1.73011	0.549***	0.07813	1.73124
				(16.18)			(16.30)			(15.39)			(15.43)		
female				-0.0271	-0.004	0.973	-0.0264	-0.004	0.974	-0.0201	-0.0029	0.98009	-0.0196	-0.0028	0.98063
				(-0.87)			(-0.85)			(-0.64)			(-0.62)		
unemployed				-0.214*	-0.031	0.807	-0.203*	-0.030	0.816	-0.215*	-0.0305	0.80662	-0.217*	-0.0308	0.80528
				(-2.24)			(-2.12)			(-2.21)			(-2.22)		
disabled				-0.167*	-0.024	0.847	-0.157*	-0.023	0.855	-0.169*	-0.024	0.84436	-0.171*	-0.0244	0.84242
				(-2.19)			(-2.04)			(-2.18)			(-2.18)		
Intercept	-1.954***		0.142	-2.357***		0.095	-2.475***		71.285	-2.691***		0.06781	-2.795***		0.06109
	(-25.13)			(-9.01)			(-9.52)			(-9.92)			(-10.33)		
Pseudo R-squared		0.053			0.062			0.061			0.088			0.087	

9. References

Berry, Audrey. 2019. "The distributional effects of a carbon tax and its impact on fuel poverty: A microsimulation study in the French context", *Energy Policy,* 124:81-94

Bird, Stephen and Hernández, Diana. 2012. Policy options for the split incentive: Increasing energy efficiency for low-income renters. *Energy Policy*. 48: 506–514. doi: 10.1016/j.enpol.2012.05.053

Boardman, Brenda. 2010. *Fixing fuel poverty: Challenges and Solutions*. London: Earthscan, London.

Boardman, Brenda.1991. *Fuel Poverty: From Cold Homes to Affordable Warmth*. Front Cover. London: Belhaven Press.

Bouzarovski, Stefan. 2018. *Energy Poverty: (Dis)Assembling Europe's Infrastructural Divide*. Manchester, UK: Palgrave Macmillan, https://doi.org/10.1007/978-3-319-69299-9

Brito, Ana. 2019 October 22. Portugal desconhece quantas pessoas vivem em pobreza energética. *Público*. Available from: https://www.publico.pt/2019/10/22/economia/noticia/portugal-desconhece-numero-pessoas-situacao-pobreza-energetica-1890827 (accessed 14 March 2020).

Churchill, Sefa Awaworyi and Smyth, Russel. 2020. "Ethnic diversity, energy poverty and mediating role of trust: Evidence from household panel data for Australia". *Energy Economics*, 86(C). Doi: 10.1016/j.eneco.2020.104663.

Commission Regulation (EC) No 1982/2003 of 21 October 2003 implementing Regulation (EC) No 1177/2003 of the European Parliament and of the Council concerning Community statistics on income and living conditions (EU-SILC) as regards the sampling and tracing rules. *Official Journal* L 298, 17/11/2003 P. 0029 – 0033. Available from: https://eur-lex.europa.eu/eli/reg/2003/1982/oj (accessed 20 April 2020).

Council European of Development Bank – CEB. 2019. *Energy Poverty in Europe: How Energy Efficient and Renewables Can Help.* Paris: CEB Studies.

Department of Trade and Industry [DTI]. 2001. *The UK Fuel Poverty Strategy*, London: DTI. Available from: www.berr.gov.uk/files/file16495.pdf (accessed 30 March 2020).

European Commission (2020). Eurostat. European Union Statistics On Income And Living Conditions. Available from: https://ec.europa.eu/eurostat/web/microdata/european-union-statistics-on-income-and-living-conditions. (accessed 2 April 2020)

European Energy Network (EnR). 2019. *Position Paper on Energy Poverty in the European Union*. Roma: Italian Agency for New Technologies, Energy and Sustainable Economic Development (ENEA) Energy Efficiency Department.

EU Energy Poverty Observatory (EPOV). 2020. Understand Energy Poverty in Europe. European Commission, Directorate General for Energy. Available from: https://www.energypoverty.eu/ (accessed 30 March 2020).

European fuel Poverty and Energy Efficiency Intelligence [EPEE Project]. 2009. *Diagnosis of causes and consequences of fuel poverty in Belgium, France, Italy, Spain and United Kingdom*. Workpackage 2, Deliverable 5, Intelligent Energy, Europe.

European Partnership for Energy and Environment [EPEE]. 2016. EPEE - HVAC, Trade Association, Airconditioning, Refrigeration, Heat Pump, Brussels | Belgium

European Union. 2009a. *Directive 2009/72/EC of the European Parliament and of the Council of 13 July 2009 concerning common rules for the internal market in electricity and repealing Directive 2003/54/EC* (Electricity Directive 2009/72).

European Union. 2009b. *Directive 2009/73/EC of the European Parliament and of the Council of 13 July 2009 concerning common rules for the internal market in natural gas and and repealing Directive 2003/55/EC* (Gas Directive 2009/73).

Healy, Jonathan. 2003. Fuel Poverty and Policy in Ireland the European Union. *Studies in Public* Policy, 12:1-169

Hills, John. 2012. *Getting the Measure of Fuel Poverty*. Final Report of the Fuel Poverty Review (CASE Report 72). London, UK: Centre for Analysis of Social Exclusion, London School of Economics and Political Science. Available from: https://www.gov.uk/government/publications/final-report-of-the-fuel-poverty-review (accessed 26 March 2020).

INSEE, 2013. *Les revenus et le patrimoine des ménages*, INSEE Références. Edition 2013. Available from: https://www.insee.fr/fr/statistiques/1374287 (accessed 20 February 2020).

Isherwood, B. C. and Hancock, R. M. 1979. *Household Expenditure on Fuel: Distributional Aspects*, London: Economic Adviser's Office, DHSS.

Legendre, Bérangère, and Ricci, Olivia. 2015. “Working paper – Measuring fuel poverty in France: which households are the most fuel vulnerable”. *Energy Economics*, 49(C):620-628. http://dx.doi.org/10.1016/j.eneco.2015.01.022.

Lundqvist, Daniel. 2019. *District Energy in Sweden*, Brussels, Belgium: Euroheat & Power 2020. Available from: https://www.euroheat.org/knowledge-hub/district-energy-sweden/ (accessed 4 May 2020).

Mohr, Tanga McDaniel. 2018. Fuel poverty in the US: Evidence using the 2009 Residential Energy Consumption Survey, *Energy Economics*, 74: 360-369. https://doi.org/10.1016/j.eneco.2018.06.007

Schleich, J. .2019. “Energy efficient technology adoption in low-income households in the European Union – What is the evidence?”, *Energy Policy*, 125:196-206.

Wadud, Z., D. J., Graham, R. B. Noland. 2009. “Modelling fuel demand for different socioeconomic groups”, *Applied Energy*. 86(12):2740–2749.